MOTION VECTOR CONVERSION METHOD AND CONVERSION APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from the related Japanese Patent Application No. 2000-312309, filed Oct. 12, 2000, the entire contents of which are incorporated herein by reference.

The present application also contains the subject matter related to concurrently filed U.S. Patent Applications by Takahashi, et al. entitled "Motion Vector Conversion Method and Conversion Apparatus", based upon and claims the benefit of priority from the related Japanese Patent Application No. 2000-310836.

The related applications are assigned to the same assignee as the present application.

BACKGROUND OF THE INVENTION

This invention relates to a motion vector conversion method and a motion vector conversion apparatus for use with an image information conversion method and an image information conversion apparatus wherein the MPEG system is used to receive, through a

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satellite broadcast, a cable TV or network media such as the Internet, or process, on such storage media as an optical or magnetic disk or a flash memory, a bit stream representative of image information compressed by orthogonal transform such as discrete cosine transform and motion compensation.

In recent years, an apparatus which complies with the MPEG system wherein image information is treated as digital data and compressed by orthogonal transform such as discrete cosine transform and motion compensation making use of the redundancy unique to the image information in order to transmit and store the information with a high efficiency has been and is being popularized in both of information distribution of broadcasting stations and so forth and information reception in general homes.

Particularly, the MPEG2 (ISO/IEC 13818-2) is defined as a general purpose image coding system and is a standardized system which covers both of interlaced scanned images and progressively scanned images as well as standard resolution images and high resolution images. It is estimated that the MPEG2 is used for a wide variety of applications for professional use and for consumer use also in the future. The use of the compression system of

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MPEG2 can achieve a high compression ratio and a good picture quality, for example, for both of interlaced scanned images of a standard resolution having 720 × 480 pixels or interlaced scanned images of a high resolution having 1,920 × 1,088 pixels at 4 to 8 Mbps by allocating a code rate (bit rate) of 18 to 22 Mbps.

Although MPEG2 is directed principally to high picture quality coding suitable for broadcasting but is not ready for a lower code rate (bit rate) than that of MPEG1, that is, not ready for a coding system of a higher compression ratio. It is considered that the need for such a coding system as just described increases in the future a popularization of portable terminals proceeds. In order to cope with the need, standardization of the MPEG4 coding system has been performed. The standards for the MPEG4 image coding system have been approved as international standards as ISO/IEC 14496-2 in December 1998.

Meanwhile, it is requested to convert a bit stream which represents image compression information of MPEG2 coded once for digital broadcasting into another bit stream representative of image compression information of MPEG4 of a lower code rate (bit rate) which is more suitable for processing on a portable terminal or the

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like.

An example of a related art image information conversion apparatus which satisfies the request is shown in FIG. 1. Referring to FIG. 1, the image information conversion apparatus shown converts a bit stream representative of image compression information of MPEG2 inputted thereto into another bit stream representative of image compression information of MPEG4. In particular, the inputted bit stream representative of image compression information of MPEG2 is decoded by an MPEG2 image information decoding apparatus 1. The decoded image signal is transmitted to a resolution frame rate conversion apparatus 2, by which it is converted into an image signal having an arbitrary different resolution and frame rate. The image signal obtained by the conversion is inputted to an MPEG4 image information coding apparatus 3, by which it is coded into and outputted as a bit stream representative of image compression information of MPEG4.

In the related art image information conversion apparatus, as seen in FIG. 1, the image signal decoded in accordance with the MPEG2 decoding system is coded by the MPEG4 image information coding apparatus, and a bit stream representative of image compression information of

MPEG4 is outputted. The MPEG2 image information decoding apparatus 1 may be configured such that it performs a decoding process for both of horizontal and vertical direction components using all eighth order DCT (discrete cosine transform) coefficients of the bit stream representative of the inputted image compression information of MPEG2. However, the MPEG2 image information decoding apparatus 1 may be configured otherwise such that it performs a decoding process wherein all of eighth order coefficients in the vertical direction are used but only four lower frequency ones of eighth order coefficients in the horizontal direction are used (the decoding process is hereinafter referred to as 4 × 8 down decoding) or another decoding process wherein only four lower frequency ones of eighth order coefficients in both of the horizontal direction and the vertical directions are used (the decoding process is hereinafter referred to as 4 × 4 down decoding) in order to reduce the arithmetic operation amount and the video memory capacity and simplify down sampling processing in the following stage while suppressing the picture quality deterioration to the minimum.

According to such a related art method as described above, when the MPEG4 image information coding apparatus

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codes an image signal inputted thereto, the arithmetic

operation processing amount for detecting a motion vector

occupies approximately 60 to 70 % of the total arithmetic

operation processing amount. This gives rise to such

problems that real time processing of an image becomes

difficult, that a time delay occurs and that a large

apparatus scale is required.

As a countermeasure for solving such problems as

just described, the inventors have proposed an image

information conversion apparatus shown in FIG. 2.

Particularly, the inventors have filed the following

applications for patent in Japan relating to the image

conversion apparatus shown in FIG. 2.

Japanese Patent Application No. 2000-129002 "Motion

Vector Conversion Apparatus and Method": This application

discloses a technique wherein information of each of

macro blocks of MPEG2 is used to select an motion vector

of MPEG 2 of that one of macro blocks of MPEG2 which

exhibits the highest coding efficiency to produce a

motion vector of MPEG4.

Japanese Patent Application No. 2000-132915 "Motion

Vector Conversion Apparatus and Method": This application

discloses a technique wherein information of each of

macro blocks is used to select, based on lengths of

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motion vectors, a motion vector of MPEG2 of that one of macro blocks of MPEG2 which exhibits the highest coding efficiency to produce a motion vector of MPEG4.

Japanese Patent Application No. 2000-191616 "Motion Vector Conversion Apparatus and Method": This application discloses a technique wherein information of each of macro blocks is used to produce a P-VOP motion vector for an intra-macro block of MPEG2.

FIGS. 3A and 3B illustrate a correlation between a motion vector in a bit stream representative of image compression information of MPEG2 and a motion vector in a bit stream representative of image compression information of MPEG4 and particularly show images of a current frame before and after resolution conversion, respectively. When the resolution of an image is converted, a horizontal component of a motion vector from the position in the preceding frame to a position in the current frame after the conversion can be determined from a horizontal component of a motion vector before the resolution conversion and the resolution conversion rate in the horizontal direction of the image. A vertical component of the motion vector after the resolution conversion can be determined from a vertical component of a motion vector before the resolution conversion and the

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resolution conversion rate in the vertical direction of the image. In other words, the motion vector before the resolution conversion and the motion vector after the conversion have a high correlation. The correlation can be utilized to determine the motion vector after the resolution conversion from the motion vector before the resolution conversion.

In particular, the image information conversion apparatus of FIG. 2 simply converts a motion vector in a bit stream representative of image compression information of MPEG2 inputted thereto into a motion vector of MPEG4 making use of parameters such as a motion vector of a macro block of MPEG2 and a macro block type. In an MPEG4 image information coding apparatus 7, detection of a motion vector is not performed, but image coding using motion vectors obtained by conversion is performed. As a result, the MPEG4 image information coding apparatus 7 does not perform motion detection, and consequently, the processing amount is reduced significantly.

By performing conversion from a motion vector of MPEG2 into a motion vector of MPEG4 and adopting a parameter used for decoding of MPEG2 or a parameter after conversion in addition to a motion vector in this manner,

the processing amount of the MPEG4 image information

coding apparatus 7 can be reduced. Consequently, the time

delay by the MPEG4 image information coding apparatus 7

can be reduced.

The bit stream representative of the inputted image

compression information of MPEG2 illustrated in FIGS. 3A

and 3B undergoes decoding processing by an MPEG2 image

information decoding apparatus 4 of FIG. 2, and a bit

stream representative of image compression information of

MPEG4 is outputted. The MPEG2 image information decoding

apparatus 4 may be configured such that it performs a

decoding process for both of horizontal and vertical

direction components using all eighth order DCT

coefficients of the bit stream representative of the

inputted image compression information of MPEG2. However,

the MPEG2 image information decoding apparatus 4 may be

configured otherwise such that it performs 4 × 8 down

decoding or 4 × 4 down decoding in order to reduce the

arithmetic operation amount and the video memory capacity

and simplify down sampling processing in the following

stage while suppressing the picture quality deterioration

to the minimum. The image signal outputted from the MPEG2

image information decoding apparatus 4 is sent to a

resolution frame rate conversion apparatus 5, in which

resolution and frame conversion are performed and then an image signal having a resolution suitable for image coding of MPEG4 is produced with an image size adjustment flag inputted thereto from the outside. The thus produced image signal is outputted from the resolution frame rate conversion apparatus 5.

More particularly, the resolution frame rate conversion apparatus 5 first performs resolution conversion of the image signal inputted thereto from the MPEG2 image information decoding apparatus 4 by means of a resolution frame converter. Here, an example of resolution conversion wherein the resolution is reduced to 1/2 for both of the vertical and horizontal directions is described. As seen in FIG. 4, in the down sampling in the vertical direction, first fields or second fields of inputted interlaced scanned images are extracted to convert the images into progressively scanned images. In the down sampling in the horizontal direction, a down sampling filter is used to convert each image into an image of a 1/2 resolution. Further, in order to achieve a low bit rate, not only compression by resolution conversion is performed, but also first fields or second fields only of I/P pictures are extracted to lower the frame rate in the temporal direction. For example, I, B,

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B and P pictures of MPEG2 shown in FIG. 4 are converted into the first fields of the I and P pictures by resolution and frame rate conversion. The images obtained by the resolution and frame conversion include a number of pixels arranged in numbers of rows and columns equal to multiples of 16 so that they can be coded in accordance with a picture coding method of MPEG4. To this end, a circuit for supplementing or removing pixels is employed to supplement or remove pixels in accordance with an image size adjustment flag inputted from the outside.

The image size adjustment flag is inputted from the outside of the resolution frame rate conversion apparatus 5 and is used for discrimination of whether pixels should be supplemented to or removed from an image when the pixel number in the rows or columns of the image is not a multiple of 16.

A process for an image with the image size adjustment flag is described with reference to FIG. 5. If it is assumed that the resolution of an image outputted from the MPEG2 image information decoding apparatus 4 is m × n pixels, then while both of m and n are multiples of 16, m/2 and n/2 by down sampling to 1/2 in the vertical and horizontal directions are multiples of 16 or have the

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remainder of 8 pixels when they are divided by 16. Where both of m/2 and n/2 are multiples of 16, the image complies with the MPEG4 coding system, and therefore, no processing is performed for the image. In any other case, the image does not comply with the MPEG4 coding system, and therefore, it is necessary to process the image with the image size adjustment flag. The image size adjustment flag provides two choices of supplementation and removal of pixels. When m/2 or n/2 is divided by 16, if the remainder is 8 pixels, then if removal of pixels is selected, then the remaining 8 pixels are removed. In other words, the resulting output image has m/2 - 8 or n/2 - 8 rows or columns. On the other hand, if supplementation of pixels is selected, then 8 pixels produced newly, 8 pixels copied from the original image or 8 pixels suitable for the image are added to the top or the bottom of the rows or columns of the image. Therefore, the output image has m/2 + 8 or n/2 + 8 rows or columns. As a result, the horizontal and vertical resolutions of the image after the conversion become multiples of 16, and an image having a size compliant with the coding system of MPEG4 is outputted.

Referring back to FIG. 2, the inputted bit stream representative of image compression information of MPEG2

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undergoes variable length decoding by the MPEG2 image

information decoding apparatus 4. Further, macro block

motion vectors only of P pictures and other parameters

such as the macro block type are extracted from the bit

stream by the MPEG2 image information decoding apparatus

4 and transmitted to a motion vector conversion apparatus

6.

A motion vector conversion method by the motion

vector conversion apparatus 6 is described with reference

to FIGS. 6A and 6B. Each of squares defined by solid

horizontal and vertical lines in FIGS. 6A and 6B

indicates a macro block. FIG. 6A shows an image outputted

from the MPEG2 image information decoding apparatus 4,

that is, an image before resolution conversion. FIG. 6B

shows an image obtained by converting the vertical and

horizontal resolutions of the image of FIG. 6A into 1/2

by means of the resolution frame rate conversion

apparatus 5. For example, a macro block of 16 × 16 pixels

(hereinafter referred to as 16 × 16 macro block)

indicated with slanting lines at the left top corner of

the image of FIG. 6A before the conversion is converted

into a block of 8 × 8 pixels (hereinafter referred to as

8 × 8 block) indicated with slanting lines at the left

top corner of the image of FIG. 6B. Further, four 16 × 16

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macro blocks screened in FIG. 6A are individually

converted, by resolution conversion, into four 8 × 8

blocks as screened in FIG. 6B, and one 16 × 16 macro

block is formed from the four 8 × 8 macro blocks. Since

the correlation between motion vectors before and after

the resolution conversion is high, a motion vector of an

8 × 8 block after the conversion can be determined from a

motion vector of a 16 × 16 macro block before the

conversion. Further, a 16 × 16 motion block is determined

from four 8 × 8 motion vectors. Consequently, four 8 × 8

motion vectors and one 16 × 16 motion vectors for use for

coding in accordance with the image coding system of

MPEG4 are produced.

A principle of operation of motion vector

conversion is described with reference to FIG. 7 which

shows a detailed configuration of the motion vector

conversion apparatus 6 of the image information

conversion apparatus of FIG. 2. Such parameters as a

motion vector and an image size in the inputted bit

stream representative of image compression information of

MPEG2 are used to produce an 8 × 8 motion vector before

modification by an MPEG2 16 × 16 motion vector to 8 × 8

motion vector conversion apparatus 8.

A principle of operation of the MPEG2 16 × 16

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motion vector to 8 × 8 motion vector conversion apparatus

8 is described with reference to a flow chart of FIG. 8.

The MPEG2 16 × 16 motion vector to 8 × 8 motion vector

conversion apparatus 8 operates in the following manner

based on a motion vector and a macro block type of an

inputted macro block of MPEG2. Since a bit stream of

interlaced scanned image compression information of MPEG2

usually uses a frame structure, a conversion method which

only includes processing of a bit stream of a frame

structure is described here.

In step ST-1, the MPEG2 16 × 16 motion vector to 8

× 8 motion vector conversion apparatus 8 discriminates,

based on the motion vector and the macro block type of

the inputted macro block of MPEG2, which one of an intra-

macro block, a skip macro block and an inter-macro block

the macro block is. If the macro block is an intra-macro

block, then it is assumed that an 8 × 8 block after

resolution conversion of the intra-macro block of MPEG2

has a motion vector. As processing for the intra-macro

block of MPEG2, in step ST-2, the motion vector of the 8

× 8 block is set to 0 first, and then an intra-mode flag

is provided in order to allow processing by a MPEG2

intra-macro block motion vector modifier 11 to be

performed. In MPEG2, when the macro block is an intra-

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macro block, an intra-mode flag is set.

If the macro block otherwise is a skip macro block, then the motion vector of each block is set to 0.

A concept of motion vector conversion where the macro block is an inter-macro block and the image has a frame structure and frame prediction is used is described with reference to FIGS. 9A and 9B. FIG. 9A shows an image before resolution conversion while FIG. 9B shows the image after the resolution conversion. As described hereinabove with reference to FIGS. 3A and 3B, a horizontal component of a motion vector after conversion is determined from a horizontal component of a motion vector before the conversion and a resolution conversion rate in the horizontal direction of the image. A vertical component of the motion vector is determined from a vertical component of the motion vector before the conversion and a resolution conversion rate in the vertical direction of the image. In particular, when the resolution in the horizontal direction is converted into 1/2, also the horizontal component of the motion vector after the conversion becomes 1/2 that before the conversion. When the resolution in the vertical direction is converted into 1/2, also the vertical component of the motion vector after the conversion becomes 1/2 that

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before the conversion.

The motion vector (8, 12) before conversion illustrated in FIG. 9A changes to a motion vector (4, 6) after the conversion illustrated in FIG. 9B. It is to be noted that, in FIGS. 9A and 9B, the distance between middle values (half pixels) of integer pixels is represented by 1. In the image before the resolution conversion shown in FIG. 9A, each dark circle indicates the position of an integer pixel, and each rhomb indicates the position of a half pixel. In the image after the resolution conversion shown in FIG. 9B, a half pixel is indicated by a blank circle. As can be seen from FIGS. 9A and 9B, a motion vector indicated at the position of an integer pixel before conversion is indicated at the position of an integer pixel or a half pixel after the conversion, but a motion vector indicated at the position of a half pixel before the conversion does not have a pixel referred to thereby after the resolution conversion. Therefore, if a motion vector before conversion indicates the position of a half pixel, then also the motion vector after conversion is changed so as to indicate the position of a half pixel of a predictive image. Since a decoded image signal originally includes some distortion arising from quantization, if it

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is used as it is as a predictive image, then the prediction efficiency is deteriorated and may sometimes cause picture quality deterioration. In order to reduce such prediction efficiency deterioration, a half pixel accuracy wherein pixels on a reference screen which corresponds to a low-pass filter are linearly interpolated at 1:1 is sometimes selected so that the picture quality deterioration may be prevented. Accordingly, also in coding in accordance with the image coding system of MPEG4, in order to augment the prediction efficiency and prevent the picture quality deterioration, if a motion vector of MPEG4 indicates the position of a half pixel, then also upon conversion into a format of MPEG4, it is converted so that the motion vector may indicate the position of a half pixel. A corresponding relationship between motion vectors before and after conversion is illustrated in a table of FIG. 10.

FIGS. 11A and 11B illustrate a concept of motion vector conversion where an image has a frame structure and field prediction, particularly first field prediction, is used. A horizontal component of a motion vector is processed in a similar manner as in the image of FIGS. 10A and 10B. For the vertical direction, the first fields are extracted to allow conversion of the

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resolution into 1/2. Since also the prediction used is the first field prediction, a motion vector before conversion becomes a motion vector after the conversion as it is.

A concept of motion vector conversion where an image has a frame structure and second field prediction is used is illustrated in FIGS. 12A, 12B and 13. When resolution conversion is performed, since only the first field is extracted, pixel values of the first field are used as a reference image after conversion. Therefore, temporal and spatial modification of a motion vector is performed so that pixel values of the second field used as a predictive picture in MPEG2 are used for first field prediction after resolution conversion. FIGS. 12A and 12B illustrate a technique of spatial modification used to convert pixel values of second field prediction approximately into pixel values of first field prediction. FIG. 12A illustrates a motion vector before resolution conversion while FIG. 12B illustrates a motion vector after the resolution conversion. In particular, "1" is added to a vertical component of a motion vector. As can be seen from FIGS. 12A and 12B, if "1" is added to a vertical component of a motion vector determined by second field prediction, then the second field is shifted

by one row distance so that it comes to a spatial position similar to that of the first field and the motion vector becomes a motion vector like a motion vector determined by first field prediction in the space. The expression (1) given below represents a vertical component of a motion vector MV_{top} where the second field at a spatial position positioned at a similar position to that of the first field by spatial modification, that is, an approximate first field, is used for prediction:

Vertical component: approximate MV_{top} = MV_{bottom} + 1

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(1)

Meanwhile, interlaced scanned image compression information of MPEG2 exhibits some displacement in time between the first field and the second field. Therefore, modification for the time displacement between the first field approximated from the second field and the actual first field is performed. FIG. 13 illustrates a temporal positional relationship of different fields. Here, if the interval between the first field and the second field is represented by 1 and the interval between the second field of an I picture and the first field of a P picture is represented by $\underline{a}$, then the value $\underline{a}$ exhibits an odd number like 1, 3, 5, 7, …. It is to be noted that, where

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a is 1, pictures are I, P, P, P, … pictures. A time modified motion vector MV' is given by the following expression (2):

Vertical component: MV' =

$$\{(a + 1)/a\}\text{approximate } MV_{top} \qquad …$$

(2)

By substituting the expression (1) into the expression (2), the vertical component of the motion vector after the conversion is given by the following expression (3):

Vertical component: MV' =

$$\{(a + 1)/a\}(MV_{bottom} + 1) \qquad …$$

(3)

It is to be noted that the horizontal component of the motion vector after the conversion can be determined by multiplying the motion vector before the conversion by $(a + 1)/a$, performing temporal modification and then performing the calculation illustrated in the table of FIG. 10.

According to circumstances, spatial modification may be performed for the vertical component of the motion vector after the temporal modification is performed. The vertical component of the motion vector MV' in this instance is given by the expression (4) given below. It

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is to be noted that, if spatial and temporal modification is performed for the horizontal component (time modification is performed after spatial modification is performed), then the horizontal component exhibits a similar value to that obtained when temporal and spatial modification is performed (spatial modification is performed after temporal modification is performed).

Vertical component: $MV' = \{(a + 1)/a\}MV_{bottom} + 1$

...

(4)

The difference between the expression (3) and the expression (4), that is, the difference between the vertical components of the motion vector when spatial and temporal modification is performed and when temporal and spatial modification is performed, is 1/a. Accordingly, since the influence of the difference differs depending upon the value of a, modification methods in two cases wherein a is equal 1 and wherein a is 3, 5, 7, ... are described.

First, a modification method where a = 1 is described. By substituting 1 into a of the expression (3), the vertical component of the motion vector is determined as given by the following expression (5):

Vertical component: $MV' = 2 \times (MV_{bottom} + 1)$ ... (5)

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By substituting 1 into <u>a</u> of the expression (4), the vertical component of the motion vector is determined as given by the following expression (6):

Vertical component: $MV' = 2 \times (MV_{bottom} - 1) \quad \ldots \quad (6)$

As a result, if 0, 1, 2, … are substituted into the motion vector MV_{bottom} before the conversion, then such even numbers as 2, 4, 6, … are obtained as the value according to the expression (5). On the other hand, such odd numbers as 1, 3, 5, … are obtained as the value according to the expression (6). In other words, if spatial and temporal modification is performed, then irrespective of whether the motion vector before the conversion is indicated at the position of an integer pixel or at the position of a half pixel, the motion vector after the conversion comes to the position of a half pixel. Accordingly, in order to cause a motion vector, which is indicated at the position of an integer pixel before conversion, to come to the position of an integer pixel also after the conversion, spatial and temporal conversion is performed. On the other hand, in order to cause a motion vector, which is indicated at the position of a half pixel before conversion, to come to the position of a half pixel also after the conversion, temporal and spatial conversion is performed. In short,

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spatial modification and temporal modification are used

alternately for motion vectors before conversion to

convert them into motion vectors after the resolution

conversion or to perform temporal and spatial

modification for the motion vectors before the conversion.

After the motion vector conversion process

described above comes to an end, an 8 × 8 motion vector

of MPEG4 before modification is outputted. The 8 × 8

motion vector outputted is transmitted to an image size

adjustment flag based motion vector adjuster 9 (FIG. 7),

by which it is modified with an image size adjustment

flag inputted thereto from the outside to a motion vector

suitable for an image size. The resulting motion vector

is outputted from the image size adjustment flag based

motion vector adjuster 9.

Operation of the image size adjustment flag based

motion vector adjuster 9 is described with reference to a

flow chart of FIG. 14. In step ST-11, the image size

adjustment flag based motion vector adjuster 9

discriminates whether both of m/2 and n/2 where the input

image has a size of m × n pixels are multiples of 16. If

both of m/2 and n/2 are multiples of 16, then the image

size adjustment flag based motion vector adjuster 9

outputs the 8 × 8 motion vector of MPEG4 outputted from

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the motion vector conversion apparatus 6 as it is without

processing the same. If m/2 or n/2 is not a multiple of

16, the image size adjustment flag based motion vector

adjuster 9 uses the image size adjustment flag inputted

from the outside to discriminate whether or not pixels

should be removed in step ST-12. If pixels should be

removed, then the image size adjustment flag based motion

vector adjuster 9 does not output the 8 × 8 motion vector

of the eight pixels removed but outputs another 8 × 8

motion vector. If it is discriminated in step ST-12 that

pixels should not be removed, then the image size

adjustment flag based motion vector adjuster 9

discriminates in step ST-13 whether or not pixels should

be supplemented. If pixels should be supplemented, then

the image size adjustment flag based motion vector

adjuster 9 sets an 8 × 8 motion vector of eight pixels

supplemented to 0 and outputs the motion vector of 0

together with the other inputted 8 × 8 motion vectors.

Referring back to FIG. 7 again, the 8 × 8 motion

vector outputted from the image size adjustment flag

based motion vector adjuster 9 and suitable for the image

size is converted by an MPEG4 8 × 8 motion vector to

MPEG4 16 × 16 motion vector conversion apparatus 10 or an

MPEG4 8 × 8 motion vector to MPEG4 16 × 16 motion vector

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conversion apparatus 15 shown in FIG. 16.

The motion vector conversion apparatus 10 of FIG. 7 divides the sum of motion vectors of those of four blocks cooperatively forming a macro block which are converted from a macro block which is not an intra-macro block b the number of those blocks to calculate an average motion vector and outputs the average motion vector as a 16 × 16 motion vector.

This is described with reference to FIG. 16. As a first method, the MPEG4 8 × 8 motion vector to MPEG4 16 × 16 motion vector conversion apparatus 15 selects, from among 8 × 8 motion vectors of MPEG4 for the macro block produced by an MPEG2 16 × 16 motion vector to MPEG4 8 × 8 motion vector conversion apparatus 12, the motion vector produced from that one of the pertaining macro blocks which is considered to have the highest coding efficient, and outputs the selected motion vector as a 16 × 16 motion vector of MPEG4.

The discrimination of the coding efficiency is performed based on information of the individual macro blocks stored in a macro block information buffer 14 and representative of image compression information of MPEG2 inputted to the image information conversion apparatus.

In short, the first method determines that one of

four macro blocks which includes the least number of non-zero DCT coefficients has the highest coding efficiency. A second method determines that one of four macro blocks which includes the least number of bits allocated to DCT coefficients of brightness components has the highest coding efficiency. A third method determines that one of four macro blocks which includes the least number of bits allocated to DCT coefficients has the highest coding efficiency. A fourth method determines that one of four macro blocks which includes the least total number of bits allocated to the macro block including motion vectors and so forth has the highest coding efficiency. A fifth method determines that one of four macro blocks which has the smallest allocated quantization scale has the highest coding efficiency. A fifth method determines that one of four macro blocks which has the lowest complexity has the lowest coding efficiency. The complexity X allocated to each macro block is calculated in accordance with the following expression (7) using the quantization scale Q allocated to the macro block and the bit number B of the macro block:

$$X = Q \cdot B$$

(7)

where B may be the bit number allocated to the entire

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macro block, or may be the bit number allocated to DCT

coefficients or else may be the bit number allocated to

DCT coefficients allocated to brightness components.

Referring back to FIG. 16, as the second method,

the MPEG4 8 × 8 motion vector to MPEG4 16 × 16 motion

vector conversion apparatus 15 counts, from among 8 × 8

motion vectors of MPEG4 for the macro blocks produced by

the MPEG2 16 × 16 motion vector to MPEG4 8 × 8 motion

vector conversion apparatus 12, that motion vector

produced from the macro block which is considered to have

the highest weight twice in an overlapping relationship,

and determines that one of the totaling five 8 × 8 motion

vectors which has a length of a middle value has the

highest coding efficiency and selects and outputs the 8 ×

8 motion vector as a 16 × 16 motion vector of MPEG4. Here,

for the comparison in length between motion vectors, the

sum of the squares of the lengths in the horizontal

direction and the vertical direction is used, but a

process of determining a square root is omitted.

The discrimination of the weight is performed based

on information of the individual macro blocks of the bit

stream stored in the macro block information buffer 14

and representative of image compression information of

MPEG2 inputted to the image information conversion

apparatus.

In particular, a first method determines that one of four macro blocks which includes the least number of non-zero DCT coefficients has the highest weight. A second method determines that one of four macro blocks which includes the least number of bits allocated to DCT coefficients of brightness components has the highest weight. A third method determines that one of four macro blocks which includes the least number of bits allocated to DCT coefficients has the highest weight. A fourth method determines that one of four macro blocks which includes the least total number of bits allocated to the macro block including motion vectors and so forth has the highest weight. A fifth method determines that one of four macro blocks which has the smallest allocated quantization scale has the highest weight. A fifth method determines that one of four macro blocks which has the lowest complexity has the lowest weight. The complexity X allocated to each macro block is calculated in accordance with the following expression (7) using the quantization scale Q allocated to the macro block and the bit number B of the macro block:

$$X = Q \cdot B \qquad \cdots$$

(8)

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where B may be the bit number allocated to the entire macro block, or may be the bit number allocated to DCT coefficients or else may be the bit number allocated to DCT coefficients allocated to brightness components.

Referring back to FIG. 7 again, the 8 × 8 motion vectors suitable for the image size outputted from the image size adjustment flag based motion vector adjuster 9 are inputted to the MPEG2 intra-macro block motion vector modifier 11. The 8 × 8 motion vector of each block converted from a macro block which has been an intra-macro block in the bit stream representative of image compression information of MPEG2 is modified by being replaced with the 16 × 16 motion vector determined by the MPEG4 8 × 8 motion vector to MPEG4 16 × 16 motion vector conversion apparatus 10. The 8 × 8 motion vectors after the modification and the 16 × 16 motion vector determined by the MPEG4 8 × 8 motion vector to MPEG4 16 × 16 motion vector conversion apparatus 10 are outputted as MPEG4 motion vectors.

A principle of operation of the motion vector modification is described with reference to FIG. 15 which shows a detailed configuration of the MPEG2 intra-macro block motion vector modifier 11 of FIG. 7. An 8 × 8 motion vector suitable for an image size is inputted to

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the MPEG2 intra-macro block motion vector modifier 11.

When the intra-mode flag is in a set state, that is, when

the macro block is an intra-macro block in the bit stream

which represents image compression information of MPEG2,

a movable contact m of a switch SW is connected to a

fixed contact a side, and the motion vector of the 8 × 8

block converted from the intra-macro block is replaced by

a replacement apparatus PK with the 16 × 16 motion vector

determined by the MPEG4 8 × 8 motion vector to MPEG4 16 ×

16 motion vector conversion apparatus 10. In this

instance, the motion vector of the 8 × 8 block may

alternatively be replaced with a motion vector converted

from a motion vector of an inter-macro block present

around the intra-macro block, or otherwise may be

replaced with a motion vector converted from a motion

vector of an inter-macro block which is nearest to the

intra-macro block. It is to be noted that, if all of the

four blocks are converted from intra-macro blocks, the

four motion vectors become 0, and also the 16 × 16 motion

vector determined by the MPEG4 8 × 8 motion vector to

MPEG4 16 × 16 motion vector conversion apparatus 10

becomes 0. Therefore, the motion vector to be used for

image coding of MPEG4 becomes 0, and the macro-block type

becomes the intra-mode type. On the other hand, when the

intra-mode flag is not in a set state, that is, when no intra-macro block of MPEG2 is involved, the movable contact m of the switch SW is connected to another fixed contact b side, and the 8 × 8 motion vector inputted is outputted as it is.

Now, a re-search of a produced motion vector is described. A concept of motion vector conversion of an inter-macro block where an image has a frame structure and field prediction is used is illustrated in FIGS. 17A and 17B. FIG. 17A shows a motion vector before resolution conversion while FIG. 17B shows the motion vector after the resolution conversion. As described hereinabove with reference to FIGS. 3A and 3B, the horizontal component of a motion vector after conversion can be determined from the horizontal component of the motion vector before conversion and a resolution conversion rate in the horizontal direction of the image. The vertical component can be determined from the vertical component of the motion vector before the conversion and the resolution conversion rate in the vertical direction of the image. In other words, if the resolution in the horizontal direction is converted into 1/2, then also the vertical component of the motion vector after the conversion becomes 1/2 that before the conversion. The motion vector

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illustrated in FIGS. 9A and 9B changes, for example, from (8, 12) before conversion to (4, 6) after the conversion. It is to be noted that, in this instance, the distance between middle values (half pixels) of integer pixels is represented by 1. Before the resolution conversion of FIG. 17A, each dark circle indicates the position of an integer pixel, and each rhomb indicates the position of a half pixel.

As can be seen from FIGS. 17A and 17B, a motion vector indicated at the position of an integer pixel before the conversion is indicated at the position of an integer pixel or a half pixel after the conversion, but a motion vector indicated at the position of a half pixel before the conversion does not have a pixel to be referred to after the resolution conversion. Therefore, where a motion vector before conversion indicates the position of a half pixel, the motion vector after the conversion is modified so that also it indicates the position of the nearest integer pixel of a predictive image. This is intended to make the center pixel of a search window coincide with an integer pixel when pixels around the motion vector are re-searched in later motion vector modification. First, that one of motion vectors of integer pixels in a search window which exhibits the

smallest prediction error is determined, and then half

pixel values around the integer pixel are searched

thereby to reduce the number of processing steps. A

correspondence relationship between motion vectors before

and after conversion is illustrated in FIGS. 19A and 19B.

Alternatively, it is possible to produce a half

pixel motion vector and perform a re-search around the

half pixel as seen in FIGS. 9A, 9B, 10, 11A, 11B, 12A and

12B. In this instance, however, a step of determining the

half pixel value in the search window in advance is

required, resulting in increase of the number of

processing steps.

Now, a concept of motion vector conversion of an

inter-macro block where an image has a frame structure

and first field prediction is used as the field

prediction is illustrated in FIGS. 19A and 19B. FIG. 19A

illustrates a motion vector before resolution conversion

while FIG. 19B illustrates the motion vector after the

resolution conversion. For the horizontal component of a

motion vector, a process similar to that described

hereinabove with reference to FIG. 18 is performed. For

the vertical component of the motion vector, the first

fields are extracted to allow conversion of the

resolution into 1/2. Further, since first field

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prediction is performed as the prediction, a motion

vector before the conversion becomes a motion vector

after the conversion as it is.

A concept of motion vector conversion of an inter-

macro block where second field prediction is used is

illustrated in FIGS. 20A and 20B. FIG. 20A illustrates a

motion vector before resolution conversion while FIG. 20B

illustrates the motion vector after the resolution

conversion. Since only the first fields are extracted

upon resolution conversion, after the conversion, pixel

values of the first fields are used as reference images.

Field line modification and motion vector modification in

the temporal direction are performed by a method similar

to that described hereinabove with reference to FIGS. 12A

and 12B, and thereafter, processing similar to that of

FIG. 18 is performed for the pixel values in the

horizontal direction as seen from integer pixels after

the conversion.

Now, a motion vector modification process by a re-

search is described with reference to FIG. 21. In

particular, the motion vector modification apparatus

receives a motion vector scaled by the motion vector

conversion apparatus 6 of FIG. 2 and outputs a motion

vector modified through a re-search in order to raise the

cording efficiency. Further, the motion vector
modification apparatus sets a size of a search window in
accordance with a motion vector modification direction
information flag. The motion vector modification
direction information flag is hereinafter described with
reference to FIGS. 23, 24A and 24B.

In particular, the motion vector modification
apparatus performs a re-search to modify a distortion
caused by scaling of a motion vector by the motion vector
conversion apparatus 6 in order to determine a motion
vector with a higher degree of accuracy. First, the
motion vector modification apparatus performs a motion
vector search of ±2 integer pixels in the horizontal
direction and ±1 pixel in the vertical direction around
an 8 × 8 motion vector of MPEG4 inputted thereto.
Consequently, the search window centered at the motion
vector determined by the motion vector conversion
apparatus 6 can be suppressed horizontally to 5 pixels
and vertically to 3 pixels thereby to reduce the
processing number of the motion vector search
significantly. Although the search window is set
horizontally to 5 pixels and vertically to 3 pixels as
just described, the search pixel numbers of the window in
the horizontal and vertical directions need not be

limited to them and can be selected arbitrarily. In order to reduce the search processing number, a motion vector modification direction information flag hereinafter described may be used to set the size of the search window for modification of a motion vector asymmetrically in the forward and reverse directions.

FIG. 22 shows a configuration of the motion vector conversion apparatus (related art apparatus which is not known when the present application is filed in Japan). The motion vector conversion apparatus is similar to the motion vector conversion apparatus 6 shown in FIG. 2. First, a conversion apparatus 221 performs spatial and temporal modification of a motion vector described hereinabove to produce an 8 × 8 motion vector. Then, a search apparatus 222 performs a re-search process of an 8 × 8 motion vector with regard to the 8 × 8 motion vector as described above. For example, the search apparatus 222 performs a search, for example, with a search window with two integer pixels in the horizontal and vertical directions around the reference destination of the produced 8 × 8 motion vector. Consequently, the prediction accuracy of the 8 × 8 motion vector can be improved. Then, prediction errors re-searched individually with regard to the four 8 × 8 motion vectors

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which form one macro block and the 8 × 8 motion vectors for which the re-search process has been performed are inputted to a conversion apparatus 223.

The conversion apparatus 223 discriminates that one of the four 8 × 8 motion vectors which exhibits the smallest prediction error among the prediction errors determined upon the re-search for an 8 × 8 motion vector, and allocates the discriminated motion vector to a 16 × 16 motion vector. Then, a search apparatus 224 performs a re-search process for the produced 16 × 16 motion vector in a similar manner as described above to improve the prediction accuracy of the 16 × 16 motion vector. Thus, the 8 × 8 motion vectors and the 16 × 16 motion vector of MPEG4 are produced and outputted.

The 8 × 8 motion vectors and the 16 × 16 motion vector outputted are inputted to a half pixel search apparatus 225, from which 8 × 8 and 16 × 16 motion vectors of the half pixel accuracy are outputted.

Here, the motion vector modification direction information flag mentioned hereinabove with reference to FIGS. 21 and 22 is described with reference to FIGS. 23A, 23B and 24. The motion vector modification apparatus sets a size of a re-search window in the advancing direction of a motion vector with the motion vector modification

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direction information flag. First, if the MPEG2 motion

vector before conversion is an integer pixel and also the

MPEG4 motion vector after conversion has an integer pixel

value as seen in FIG. 23A, since a pixel of the same

phase is present and no distortion occurs with the pixel

value of the motion vector, a search window for motion

vector modification is set symmetrically in the advancing

direction of the motion vector. However, if the MPEG2

motion vector before conversion has an integer pixel

value and the MPEG4 motion vector after the conversion

has a half pixel accuracy as seen in FIG. 23B, in order

to modify it to an approximate integer pixel value of

MPEG4 by carrying up in the advancing direction of the

motion vector, the search window is set so as to have a

greater part in the reverse direction to the advancing

direction of the motion vector thereby to reduce the

search processing number. For example, a search is

performed with two integer pixel values in the reverse

direction to the motion vector and with one integer pixel

value in the forward direction. Naturally, if the motion

vector of MPEG4 is set to an appropriate integer pixel

value of MPEG4 by carrying down upon motion vector

conversion, then the search window is set so as to be

greater in the forward direction with respect to the

advancing direction of the motion vector.

Also in FIGS. 24A and 24B, the MPEG2 motion vector before conversion exhibits a half pixel accuracy. Upon conversion into an MPEG motion vector, in order to modify the motion vector to the nearest integer pixel value of MPEG4, the search window of the MPEG4 motion vector modification apparatus can be set, based on the direction in which a distortion occurs, so as to be greater in the forward direction or the reverse direction with respect to the advancing direction of the motion vector similarly as in the case of FIG. 23B. Consequently, in order to reduce the processing number for motion vector re-search, the direction of the distortion of the motion vector is outputted from the motion vector conversion apparatus 6 and inputted to the motion vector modification apparatus, by which a size of a search window optimum to perform a modification search for a motion vector can be set.

The MPEG4 image information coding apparatus 7 receives an output image from the resolution frame rate conversion apparatus 5, performs coding of the output image in accordance with an image coding system of MPEG4 using the motion vector of MPEG4 outputted from the motion vector conversion apparatus 6, and outputs a bit stream representative of image compression information of

MPEG4.

In the following, a different motion vector conversion method and conversion apparatus (which is not known when the present application is filed in Japan) invented by the inventors of the invention of the present application is described.

FIG. 25 illustrates a concept of a correspondence relationship between a picture type and a VOP (Video Object Plane) type upon conversion from an MPEG2 stream into an MPEG4 stream. When a stream of MPEG2 of 30 frames per second wherein the GOP (Group Of Pictures) structure is N15M3 is to be converted into another stream of MPEG4 of 5 frames per second wherein the GOP structure is N5M1, every other ones of I and P frames are converted into MPEG4 frames. Since one GOP of N5M1 of the stream of MPEG4 corresponds to two GOPs of N15M1 of the stream of MPEG2 as seen in FIG. 25, upon conversion from MPEG2 into MPEG4, two cases are available including a case wherein a P frame is dropped and another case wherein an I frame is dropped.

First, dropping of an I frame is described with reference to FIG. 26. Since an I frame I_{n-1} between P frames P_{n-2} and P_n does not include any motion vector, the motion vector of the dropped I frame cannot be added to

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the motion vector MV_n of the pertaining macro block to synthesize a motion vector. Therefore, in the pertaining macro block, the motion vector MV_n of the macro block is spatially and temporally modified by scaling in accordance with the method described hereinabove in the description of the related art, and then the length of the motion vector MV_n in the temporal direction is extended to twice so as to refer to a VOP of MPEG4 converted from an I or P frame preceding to the dropped P frame to obtain a motion vector $2*MV_n$. Consequently, the VOP converted from the I or P frame immediately preceding to the frame whose motion vector of the P-VOP is referred to. In this manner, scaling by spatial and temporal modification is performed, and then, a motion vector extended to twice in the temporal direction is produced and outputted as an 8 × 8 motion vector.

Now, dropping of a P frame is described with reference to FIGS. 27, 28, 29 and 30. Referring first to FIG. 27, there is illustrated a concept of a process when a P frame is dropped. Since a P frame P_{n-1} to be dropped between an I frame I_{n-2} and a P frame P_n has a motion vector MV_{n-1}, the motion vector MV_{n-1} of the P frame to be dropped is added to the motion vector MV_n of the pertaining macro block to produce a motion vector MV_{n-1} +

MV_{n1} which refers to the frame preceding to the P frame to be dropped.

As shown in FIG. 28, a motion vector of the pertaining macro block refers to the frame to be dropped, and in this case, the pertaining reference area overlaps with a plurality of macro blocks to be referred to.

FIG. 29 illustrates in what manner the area MB_0 for reference overlaps with a plurality of macro blocks. As can be seen from FIG. 29, the area MB_0 for reference may possibly overlap with one, two or four macro blocks (MB). The portions at which the area MB_0 for reference overlaps with the macro blocks MB are denoted by refMB#0, refMB#1, refMB#2 and refMB#3. Motion vectors, macro block modes and prediction modes, bit numbers or quantization scales of the P frame to be dropped are stored in a unit of a frame into a motion vector and macro block information buffer in order to allow later synthesis of motion vectors by addition. With regard to the pertaining macro block for which motion vector conversion from MPEG2 to MPEG4 is to be performed, coordinates to be referred to by the motion vector on the dropped P frame are calculated. As seen from FIG. 29, depending upon the coordinates referred to by the motion vector, the macro block MB_0 for reference may possibly overlap with one, two

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or four macro blocks (MB) of the reference P frame

dropped. Where the macro block MB_0 for reference overlaps

with a plurality of macro blocks, the coding efficiencies

of the macro blocks are re-arranged in a descending order

based on a parameter X determined in advance.

In particular, in a first method, the parameter X

is the "number of pixels in each of portions, overlapping

with the macro block in the P frame next to the P frame

to be dropped, of macro blocks in the P frame to be

dropped"; in a second method, the parameter X is the

"number of pixels in each of portions, overlapping with

the macro block in the P frame next to the P frame to be

dropped, of macro blocks in the P frame to be dropped

/macro block bit number"; in a third method, the

parameter X is the "number of pixels in each of portions,

overlapping with the macro block in the P frame next to

the P frame to be dropped, of macro blocks in the P frame

to be dropped/Q-scale" (the Q scale signifies a macro

block quantization scale); in a fourth method, the

parameter X is the "number of pixels in each of portions,

overlapping with the macro block in the P frame next to

the P frame to be dropped, of macro blocks in the P frame

to be dropped/(macro block bit number × Q-scale"; in a

fifth method, the parameter X is 1/macro block bit

number; in a sixth method, the parameter X is the (1/Q-scale); and in a seventh method, the parameter X is 1/(macro block bit number $\times$ Q-scale). The highest one of the values of the parameter X is determined as a maximum value, and the lowest one of the values of the parameter X is determined as a minimum value. In FIG. 28, the parameters X according to the first to fourth methods described above are illustrated. In FIG. 28, "MB$_{overlapped\ area}$" denotes the number of pixels in each of portions, overlapping with the macro block in the P frame next to the P frame to be dropped, of macro blocks in the P frame to be dropped"; "Coef bits" denotes the macro bit number; and "Q-scale" denotes the macro block quantization scale.

Now, a motion vector synthesis algorithm where a P frame is dropped is described with reference to a flow chart of FIG. 30. First, from among one, two or four macro blocks (MB) in the P frame to be dropped, which overlap with an MPEG2 motion vector of the pertaining area in order to be referred to, those in which the macro block (MB) mode is Not Coded (whose DCT coefficients are not coded) and a number of pixels in the overlapping macro block is greater than a threshold value T are searched for (step ST-21). The threshold value T is set, for example, to 100 pixels. If at least one macro block

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(MB) of Not Coded is included in the overlapping macro blocks, then the motion vector MV_{n-1} of the macro block (MB) of Not Coded having the lowest macro block (MB) address is selected (step ST-22).

If a macro block of Not Coded (whose DCT coefficients are not coded) is not included in the one, two or four macro blocks in the P frame to be dropped, which overlap with the MPEG2 motion vector of the pertaining area in order to be referred to, then macro blocks in which the macro block (MB) mode is No MC (no motion compensation) and a number of pixels in the overlapping macro block is greater than the threshold value T are searched for (step ST-23). The threshold value T is set, for example, to 100 pixels. If at least one macro block of No MC is included in the overlapping macro blocks, then the motion vector MV_{n-1} of the macro blocks of No MC having the lowest macro block address is selected (step ST-24).

If a macro block of Not Coded (whose DCT coefficients are not coded) or No MC (No motion compensation) is not included in the one, two or four macro blocks which overlap with the MPEG2 motion vector of the pertaining macro block in order to be referred to, then it is discriminated in order beginning with the

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macro block which has the maximum parameter X described

above whether or not the macro block (MB) mode of each of

the macro blocks is an intra-macro block (MB (step ST-25).

If the reference macro block is an intra-macro block,

then it is discriminated whether or not the macro block

which has the second maximum parameter X is an intra-

macro block and it is discriminated whether or not all of

the macro blocks which overlap with the pertaining macro

block are intra-macro blocks in order to be referred to

(step ST-26). If all of the macro blocks which overlap

with the pertaining macro block in order to be referred

to are intra-macro blocks, then a zero motion vector (MV)

is selected (step ST-27).

If a macro block which is not an intra-macro block

is searched out in step ST-25, then the processing

advances to a next discrimination routine. In particular,

it is discriminated whether or not the prediction mode of

the macro block which is not an intra-macro block is

field prediction wherein the second field is referred to

(step ST-28). If the field prediction wherein the second

field is referred to is used, then similar discrimination

is performed for the reference block which has the second

maximum parameter X (step ST-29). If N (the number of

intra-macro blocks) reference macro blocks use the field

prediction wherein the second field is referred to, then

the motion vector MV_{n-1} of the reference macro block (MB)

which has the highest parameter X (step ST-30) is

selected. N is a number determined in advance and has the

value of 1, 2, 3 or 4. If a macro block which does not

use the field prediction wherein the second field is

referred to is searched out, then the motion vector MV_{n-1}

of the macro block is selected (step ST-31). A motion

vector to be added to the motion vector of the pertaining

macro block is selected in this manner.

FIG. 31 illustrates temporal modification of a

motion vector which refers to the second field. Scaling

(resolution conversion) of the motion vector obtained by

the addition is performed in accordance with a method

similar to the scaling method wherein spatial and

temporal modification is performed for a motion vector

described hereinabove in the description of the related

art. Consequently, if the motion vector obtained by the

addition refers to the second field of the reference

frame, then field modification is performed for the

vertical component of the motion vector, and then the

motion vector is extended by an amount equal to one field

distance in the temporal direction as vector modification.

As seen in FIG. 31, the field distance between the

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pertaining field and the second field to be referred to

is denoted by a, and therefore, the motion vector is

multiplied by (a + 1)/a in order to temporally modify the

same for one field. An 8 × 8 motion vector is determined

in this manner and outputted.

FIG. 32 shows a configuration of a motion vector

conversion apparatus which drops an I frame. Referring to

FIG. 32, the motion vector conversion apparatus is

similar to the motion vector conversion apparatus 6

described hereinabove with reference to FIG. 2. First,

motion vectors of MPEG2 are inputted to a motion vector

spatial-temporal modification apparatus 321, by which

spatial and temporal modification of the motion vectors

is performed in a similar manner as described hereinabove

to produce 8 × 8 motion vectors. Then, the 8 × 8 motion

vectors are inputted to an 8 × 8 MV re-search apparatus

322, in which a re-search process for 8 × 8 motion

vectors is performed as described hereinabove in the

description of the related art. For example, a search

window centered at a reference destination of each of the

produced 8 × 8 motion vectors is produced with two

integer pixels in the horizontal and vertical directions,

and a search is performed within the search window.

Consequently, the prediction accuracy of the 8 × 8 motion

vector can be improved. Then, prediction errors re-searched with regard to four 8 × 8 motion vectors which form one macro block and the 8 × 8 motion vectors for which the re-search process has been performed are inputted to an 8 × 8 MV to 16 × 16 MV conversion apparatus 323.

The 8 × 8 MV to 16 × 16 MV conversion apparatus 323 discriminates that one of the four 8 × 8 motion vectors which has the lowest prediction error and allocates the discriminated motion vector to the 16 × 16 motion vector. Then, the produced 16 × 16 motion vector is inputted to a 16 × 16 MV re-search apparatus 324, by which a re-search process is performed similarly as described in the description of the related art to improve the prediction accuracy of the 16 × 16 motion vector. The 8 × 8 motion vectors and the 16 × 16 motion vector of MPEG4 produced in this manner are outputted.

FIG. 33 shows a further configuration of the motion vector conversion apparatus wherein a P frame is dropped. Referring to FIG. 33, the motion vector conversion apparatus shown is similar to the motion vector conversion apparatus 6 described hereinabove with reference to FIG. 2. First, motion vectors of MPEG2 are inputted to a changeover switch 351. The changeover

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switch 351 is switched to an MV and MB information buffer 352 side when information of a P frame to be dropped is received, but is switched to a reference MB address calculation apparatus 354 and a motion vector extension spatial-temporal modification apparatus 357 side when information of any other P frame is received.

The MV and MB information buffer 352 stores motion vector information and macro block prediction modes of P frames to be dropped in a unit of a frame and, according to circumstances, stores the bit amount and the quantization scale of each of the macro blocks. The reference MB address calculation apparatus 354 accepts motion vectors of a P frame next to a P frame to be dropped and calculates a reference position of each of the motion vectors. The reference position of the motion vector is inputted to an addition motion vector discrimination apparatus 353, by which macro blocks of the P frame to be dropped which overlap with the reference pixel are calculated based on the reference position. The addition motion vector discrimination apparatus 353 makes use of this information to perform processing based on such a technique of selecting a motion vector to be added as described above, and outputs a motion vector to be added. The outputted motion vector

is added to the motion vector of the pertaining macro

block to produce a synthesized motion vector.

Motion vectors synthesized in this manner are

inputted to a motion vector spatial-temporal modification

apparatus 355, by which spatial and temporal modification

scaling is performed for the motion vectors in a similar

manner as described hereinabove in the description of the

related art and in the paragraphs given hereinabove to

produce 8 × 8 motion vectors. the motion vector extension

spatial-temporal modification apparatus 357 and a motion

vector re-search apparatus 358 are used to determine a

motion vector in accordance with the extension method and

perform processes similar to those of the motion vector

spatial-temporal modification apparatus 321 and the 8 × 8

motion vector re-search apparatus 322, respectively.

Consequently, motion vectors are produced by them. The

motion vectors outputted from the motion vector re-search

apparatus 356 and the motion vector re-search apparatus

358 are inputted to an 8 × 8 motion vector selection

apparatus 359. The 8 × 8 motion vector selection

apparatus 359 outputs those of the motion vectors from

the motion vector re-search apparatus 356 and the motion

vector re-search apparatus 358 which have smaller

predictive residuals as 8 × 8 motion vectors. An 8 × 8 MV

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to 16 × 16 MV conversion apparatus 60 and a 16 × 16

motion vector re-search apparatus 361 operate similarly

to the 8 × 8 MV to 16 × 16 MV conversion apparatus 323

and 16 × 16 MV re-search apparatus 324 of the motion

vector conversion apparatus of FIG. 32, respectively, to

produce a 16 × 16 motion vector. The 8 × 8 motion vectors

and the 16 × 16 motion vector of MPEG4 produced in this

manner are outputted.

In this manner, when a P frame is dropped, two

different kinds of motion vectors including motion

vectors determined by extension of motion vectors of four

blocks which form one macro block and a motion vector

determined by addition of the motion vectors. A re-search

process is performed subsequently for the motion vectors

and a motion vector which exhibits the smallest

prediction error is outputted as an 8 × 8 motion vector

of MPEG4. The method of the re-search may be similar to

the method described hereinabove in the description of

the related art, and, for example, the range of search of

the search window is two integer pixels in the vertical

and horizontal directions. Consequently, two motion

vectors can be determined by a re-search for each of four

blocks which form one macro block.

Then, prediction errors of the two motion vectors

for one block are compared with each other, and one of
the motion vectors which exhibits the lower predictive
residual is outputted as an 8 × 8 motion vector. In this
manner, between motion vectors determined by the method
wherein a motion vector is extended and the method
wherein motion vectors are added, the motion vector which
has the highest coding efficiency can be selected to
produce an 8 × 8 motion vector. Thereafter, prediction
errors determined by a re-search of the four 8 × 8 motion
vectors of MPEG4 of a macro bloc are compared with one
another to discriminate the 8 × 8 motion vector which
exhibits the smallest prediction error. The 8 × 8 motion
vector which exhibits the smallest prediction error is
allocated to a 16 × 16 motion vector. Then, a re-search
is performed also for the selected 16 × 16 motion vector
similarly as in the 8 × 8 motion vector re-search method
described hereinabove to optimize the coding efficiency
of the 16 × 16 motion vector.

    . In this manner, in a procedure wherein image
information compression information of MPEG2 is inputted
to determine 8 × 8 and 16 × 16 motion vectors of MPEG4,
the motion vector conversion apparatus extends or adds
the motion vectors and performs motion vector
modification by a re-search of the scaled motion vector

information centered at each of the motion vectors.

Consequently, a reduction in coding efficiency of an

image coding apparatus of MPEG4 can be minimized.

FIG. 34 shows a yet further configuration of the

motion vector conversion apparatus. Referring to FIG. 34,

the motion vector conversion apparatus shown is similar

to the motion vector conversion apparatus 6 described

hereinabove with reference to FIG. 2. First, an MPEG4 to

MPEG2 8 × 8 MV conversion apparatus 271 performs spatial

and temporal modification of motion vectors described

above to produce 8 × 8 motion vectors. Then, a motion

vector integer pixel search apparatus 272 performs a re-

search process for each of the 8 × 8 motion vectors as

described hereinabove in the description of the related

art. For example, a search window centered at a reference

destination of each of the produced 8 × 8 motion vectors

is produced with two integer pixels in the horizontal and

vertical directions, and a search is performed within the

search window. Consequently, the prediction accuracy of

the 8 × 8 motion vector can be improved. Then, prediction

errors re-searched with regard to four 8 × 8 motion

vectors which form one macro block and the 8 × 8 motion

vectors for which the re-search process has been

performed are inputted to an 8 × 8 motion vector to 16 ×

16 motion vector conversion apparatus 273.

The 8 × 8 motion vector to 16 × 16 motion vector conversion apparatus 273 discriminates that one of the four 8 × 8 motion vectors which has the lowest prediction error among the prediction errors determined upon the 8 × 8 motion vector re-search and allocates the discriminated motion vector to the 16 × 16 motion vector. Then, the produced 16 × 16 motion vector is inputted to a motion vector integer pixel search apparatus 274, by which a re-search process is performed similarly as described hereinabove in the description of the related art to improve the prediction accuracy of the 16 × 16 motion vector. The 8 × 8 motion vectors and the 16 × 16 motion vector of MPEG4 produced in this manner are outputted.

The 8 × 8 motion vectors and the 16 × 16 motion vector of MPEG4 outputted are inputted to a half pixel search apparatus 275, from which the 8 × 8 and 16 × 16 motion vectors are outputted with a half pixel accuracy.

In this manner, in a procedure wherein image information compression information of MPEG2 is inputted to determine 8 × 8 motion vectors and 16 × 16 motion vectors of MPEG4, the motion vector conversion apparatus extends or adds the motion vectors and performs motion vector modification by a re-search of the scaled motion

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vector information centered at each of the motion vectors. Consequently, a reduction in coding efficiency of an image coding apparatus of MPEG4 can be minimized.

The motion vector conversion apparatus described hereinabove with reference to FIG. 34 converts a motion vector of MPEG2 to produce a motion vector of MPEG4. However, when it converts a motion vector of an intra-frame of MPEG2 into a motion vector of MPEG4, it does not produce motion vector information but converts the motion vector of an intra-frame of MEPG2 into an I-VOP of MPEG4 (the I-VOP signifies a frame coded in the intra-mode of MPEG4). Consequently, the motion vector conversion apparatus has a problem in that the I-VOP distance of a bit stream of MPEG4 is so small that the coding efficiency after conversion into image compression information of MPEG4 (the bit stream) is deteriorated.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a motion vector conversion method for an image information conversion method wherein a bit stream representative of interlaced scanned image compression information of MPEG2 is inputted and another bit stream representative of progressively scanned image compression information of MPEG4 is outputted, by which the cording

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efficiency in image coding of MPEG4 in the image

information conversion method can be further augmented.

It is another object of the present invention to

provide a motion vector conversion apparatus for an image

information conversion apparatus wherein a bit stream

representative of interlaced scanned image compression

information of MPEG2 is inputted and another bit stream

representative of progressively scanned image compression

information of MPEG4 is outputted, by which the cording

efficiency in image coding of MPEG4 in the image

information conversion method can be further augmented.

In order to attain the objects described above,

according to an aspect of the present invention, there is

provided a motion vector conversion method for an image

information conversion method wherein a bit stream

representative of interlaced scanned image compression

information of MPEG2 is inputted and a bit stream

representative of progressively scanned image compression

information of MPEG4 is outputted, comprising the steps

of successively accepting 16 × 16 motion vectors of MPEG2

of the inputted bit stream representative of image

compression information of MPEG2, and successively

producing 8 × 8 motion vectors of MPEG4 and 16 × 16

motion vectors of MPEG4 based on the 16 × 16 motion

vectors of MPEG2 such that every other one of P frames of the bit stream of MPEG2 is dropped to produce a bit stream of MPEG4 of a reduced frame rate and a low bit rate, the successively producing step serving also as a motion vector modification step and including a step of storing information of each of macro blocks and between blocks in the inputted bit stream representative of image compression information of MPEG2 in advance, a step of duplicating motion vectors of a P frame immediately preceding to each P frame to be dropped based on the stored information and a step of extending the duplicated motion vectors to twice in the temporal direction to produce motion vectors of MPEG4 converted from an intra-frame of MPEG2.

In the motion vector conversion method, 16 × 16 motion vectors of MPEG2 of the inputted bit stream representative of image compression information of MPEG2 are successively accepted, and 8 × 8 motion vectors of MPEG4 and 16 × 16 motion vectors of MPEG4 are successively produced based on the 16 × 16 motion vectors of MPEG2 such that every other one of P frames of the bit stream of MPEG2 is dropped to produce a bit stream of MPEG4 of a reduced frame rate and a low bit rate. Also for motion vector modification, information of each of

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macro blocks and between blocks in the inputted bit

stream representative of image compression information of

MPEG2 is stored in advance, and motion vectors of a P

frame immediately preceding to each P frame to be dropped

are duplicated based on the stored information. Then, the

duplicated motion vectors are extended to twice in the

temporal direction to produce motion vectors of MPEG4

converted from an intra-frame of MPEG2.

According to another aspect of the present

invention, there is provided a motion vector conversion

method for an image information conversion method wherein

a bit stream representative of interlaced scanned image

compression information of MPEG2 is inputted and a bit

stream representative of progressively scanned image

compression information of MPEG4 is outputted, comprising

the steps of successively accepting 16 × 16 motion

vectors of MPEG2 of the inputted bit stream

representative of image compression information of MPEG2,

and successively producing 8 × 8 motion vectors of MPEG4

and 16 × 16 motion vectors of MPEG4 based on the 16 × 16

motion vectors of MPEG2 such that every other one of I

frames and P frames of the bit stream of MPEG2 is dropped

to produce a bit stream of MPEG4 of a reduced frame rate

and a low bit rate, the successively producing step

including a step of utilizing, as a parameter for
discrimination of the coding efficiency of a motion
vector of MPEG4 converted from an intra-frame of MPEG2,
motion vector information of each of macro blocks and
between blocks of the inputted bit stream representative
of image compression information of MPEG2 converted
immediately preceding to the intra-frame to compare the
motion vector information with a prediction value of the
0 motion vector to select that one of the motion vectors
which exhibit a comparatively small prediction residual
as a motion vector having a comparatively high coding
efficiency.

According to a further aspect of the present
invention, there is provided a motion vector conversion
method for an image information conversion method wherein
a bit stream representative of interlaced scanned image
compression information of MPEG2 is inputted and a bit
stream representative of progressively scanned image
compression information of MPEG4 is outputted, comprising
the steps of successively accepting 16 × 16 motion
vectors of MPEG2 of the inputted bit stream
representative of image compression information of MPEG2,
and successively producing 8 × 8 motion vectors of MPEG4
and 16 × 16 motion vectors of MPEG4 based on the 16 × 16

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motion vectors of MPEG2 such that every other one of I

frames and P frames of the bit stream of MPEG2 is dropped

to produce a bit stream of MPEG4 of a reduced frame rate

and a low bit rate, the successively producing step

serving also as a motion vector modification step and

including a step of successively accepting 8 × 8 motion

vectors of MPEG4 converted by a motion vector conversion

method from motion vectors of MPEG2 based on motion

vector information in the inputted bit stream

representative of image compression information of MPEG2,

a step of performing a re-search for a motion vector

centered at each of the input motion vector values to

modify the motion vector, and a step of allocating that

one of each four 8 × 8 motion vectors of MPEG4

cooperatively forming a macro block which exhibits the

lowest prediction residual to a 16 × 16 motion vector to

produce the 16 × 16 motion vector.

With the motion vector conversion methods, a

further high coding efficiency in image coding of MPEG4

in an image information conversion method can be achieved.

According to a still further aspect of the present

invention, there is provided a motion vector conversion

apparatus for an image information conversion apparatus

wherein a bit stream representative of interlaced scanned

image compression information of MPEG2 is inputted and a
bit stream representative of progressively scanned image
compression information of MPEG4 is outputted, comprising
motion vector production means for accepting 16 × 16
motion vectors of MPEG2 of the inputted bit stream
representative of image compression information of MPEG2
and successively producing 8 × 8 motion vectors of MPEG4
and 16 × 16 motion vectors of MPEG4, dropping means for
dropping every other one of P frames of the inputted bit
stream of MPEG2 and supplying 16 × 16 motion vectors of
MPEG2 of the remaining I frames and P frames to the
motion vector production means so that a bit stream of
MPEG4 of a reduced frame rate and a low bit rate may be
produced by the motion vector production means, and
storage means serving also as a motion vector
modification apparatus for storing information of each of
macro blocks and between blocks in the inputted bit
stream representative of image compression information of
MPEG2 in advance, the motion vector production means
being operable to duplicate motion vectors of a P frame
immediately preceding to each P frame to be dropped based
on the information stored in the storage means and extend
the duplicated motion vectors to twice in the temporal
direction to produce motion vectors of MPEG4 converted

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from an intra-frame of MPEG2.

According to a yet further aspect of the present invention, there is provided a motion vector conversion apparatus for an image information conversion apparatus wherein a bit stream representative of interlaced scanned image compression information of MPEG2 is inputted and a bit stream representative of progressively scanned image compression information of MPEG4 is outputted, comprising motion vector production means for accepting 16 × 16 motion vectors of MPEG2 of the inputted bit stream representative of image compression information of MPEG2 and successively producing 8 × 8 motion vectors of MPEG4 and 16 × 16 motion vectors of MPEG4, dropping means for dropping every other one of I frames and P frames of the inputted bit stream of MPEG2 and supplying 16 × 16 motion vectors of MPEG2 of the remaining I frames and P frames to the motion vector production means so that a bit stream of MPEG4 of a reduced frame rate and a low bit rate may be produced by the motion vector production means, and selection means utilizing, as a parameter for discrimination of the coding efficiency of a motion vector of MPEG4 converted from an intra-frame of MPEG2, motion vector information of each of macro blocks and between blocks of the inputted bit stream representative

of image compression information of MPEG2 converted immediately preceding to the intra-frame to compare the motion vector information with a prediction value of the 0 motion vector to select that one of the motion vectors which exhibit a comparatively small prediction residual as a motion vector having a comparatively high coding efficiency.

According to a yet further aspect of the present invention, there is provided a motion vector conversion apparatus for an image information conversion apparatus wherein a bit stream representative of interlaced scanned image compression information of MPEG2 is inputted and a bit stream representative of progressively scanned image compression information of MPEG4 is outputted, comprising motion vector production means for accepting 16 × 16 motion vectors of MPEG2 of the inputted bit stream representative of image compression information of MPEG2 and successively producing 8 × 8 motion vectors of MPEG4 and 16 × 16 motion vectors of MPEG4, and dropping means for dropping every other one of I frames and P frames of the inputted bit stream of MPEG2 and supplying 16 × 16 motion vectors of MPEG2 of the remaining I frames and P frames to the motion vector production means so that a bit stream of MPEG4 of a reduced frame rate and a low bit

rate may be produced by the motion vector production means, the motion vector production means serving also as a motion vector modification apparatus and operable to successively accept 8 × 8 motion vectors of MPEG4 converted by a motion vector conversion apparatus from motion vectors of MPEG2 based on motion vector information in the inputted bit stream representative of image compression information of MPEG2, perform a re-search for a motion vector centered at each of the input motion vector values to modify the motion vector, and allocate that one of each four 8 × 8 motion vectors of MPEG4 cooperatively forming a macro block which exhibits the lowest prediction residual to a 16 × 16 motion vector to produce the 16 × 16 motion vector.

With all of the motion vector conversion apparatus, a further high coding efficiency in image coding of MPEG4 in an image information conversion method can be achieved.

The above and other objects, features and advantages of the present invention will become apparent from the following description and the appended claims, taken in conjunction with the accompanying drawings in which like parts or elements denoted by like reference symbols.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing a related art image information conversion apparatus which converts a bit stream representative of image compression information of MPEG2 into another bit stream representative of image compression information of MPEG4;

FIG. 2 is a block diagram showing an image information conversion apparatus (related art) proposed by the inventors of the present invention which converts a bit stream representative of image compression information of MPEG2 into another bit stream representative of image compression information of MPEG4;

FIGS. 3A and 3B are diagrammatic views illustrating a correlation between a motion vector in a bit stream representative of image compression information of MPEG2 and another motion vector in another bit stream representative of image compression information of MPEG4;

FIG. 4 is a diagrammatic view illustrating a principle of operation of a resolution frame rate conversion apparatus in the image information conversion apparatus of FIG. 2;

FIG. 5 is a schematic view illustrating a principle of operation of supplementing or removing a pixel of the resolution frame rate conversion apparatus in the image

information conversion apparatus of FIG. 2 in accordance

with an image frame size adjustment flag;

FIGS. 6A and 6B are diagrammatic views illustrating

a motion vector conversion method of a motion vector

conversion apparatus in the image information conversion

apparatus of FIG. 2;

FIG. 7 is a block diagram showing a detailed

configuration of the motion vector conversion apparatus

in the image information conversion apparatus of FIG. 2;

FIG. 8 is a flow chart illustrating a principle of

operation of an MPEG2 16 × 16 motion vector to MPEG4 8 ×

8 motion vector conversion apparatus in the image

information conversion apparatus of FIG. 2;

FIGS. 9A and 9B are diagrammatic views illustrating

a concept of motion vector conversion of the MPEG2 16 ×

16 motion vector to MPEG4 8 × 8 motion vector conversion

apparatus in the motion vector conversion apparatus of

FIG. 7 wherein a frame structure and frame prediction are

used;

FIG. 10 is a table illustrating handling after

conversion into an MPEG4 8 × 8 motion vector of a motion

vector of a half pixel accuracy in a bit stream

representative of image compression information of MPEG2

illustrated in FIG. 9;

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FIGS. 11A and 11B are diagrammatic views illustrating motion vector conversion wherein the image illustrated in FIG. 9 has a frame structure and first field prediction is used;

FIGS. 12A and 12B are diagrammatic views illustrating motion vector conversion wherein the image illustrated in FIG. 9 has a frame structure and second field prediction is used;

FIG. 13 is a diagrammatic view illustrating motion vector conversion wherein the image illustrated in FIG. 9 has a frame structure and second field prediction is used;

FIG. 14 is a flow chart illustrating operation of a motion vector modifier which operates with an image size adjustment flag in the motion vector conversion apparatus of FIG. 7;

FIG. 15 is a block diagram illustrating a principle of operation of the motion vector modifier shown in FIG. 7 which performs motion vector modification for an intra-macro block of MPEG2;

FIG. 16 is a block diagram showing a detailed configuration of the motion vector conversion apparatus in the image information conversion apparatus of FIG. 2;

FIGS. 17A and 17B are diagrammatic views

illustrating a concept of motion vector conversion by the MPEG2 16 × 16 motion vector to MPEG4 8 × 8 motion vector conversion apparatus, which performs a motion vector re-search, in the motion vector conversion apparatus of FIG. 7 wherein a frame structure and frame prediction are used;

FIG. 18 is a table illustrating handling after conversion into an MPEG4 8 × 8 motion vector of a motion vector of a half pixel accuracy in a bit stream representative of image compression information of MPEG2 when a motion vector re-search is performed in the motion vector conversion apparatus of FIG. 7;

FIGS. 19A and 19B are diagrammatic views illustrating a concept of motion vector conversion wherein the image when a motion-vector re-search is performed by the motion vector conversion apparatus of FIG. 7 has a frame structure and first field prediction is used;

FIGS. 20A and 20B are diagrammatic views illustrating a concept of motion vector conversion wherein the image when a motion-vector re-search is performed by the motion vector conversion apparatus of FIG. 7 has a frame structure and second field prediction is used;

FIG. 21 is a block diagram showing a motion vector modification apparatus;

FIG. 22 is a block diagram showing a motion vector re-search apparatus which performs a re-search process for an 8 × 8 motion vector and produces a 16 × 16 motion vector based on a predictive residual;

FIGS. 23A and 23B are diagrammatic views illustrating a distortion of a motion vector by spatial modification;

FIGS. 24A and 24B are diagrammatic views illustrating a distortion of a motion vector by spatial modification;

FIG. 25 is a diagrammatic view illustrating dropping of an I frame;

FIG. 26 is a diagrammatic view illustrating dropping of an I frame;

FIGS. 27 and 28 are diagrammatic views illustrating dropping of a P frame;

FIG. 29 is a diagrammatic view illustrating in what manner a reference pixel overlaps with a plurality of macro blocks;

FIG. 30 is a flow chart illustrating a motion vector synthesis algorithm where a P frame is dropped;

FIG. 31 is a diagrammatic view illustrating

temporal modification of a motion vector wherein the second field of a motion vector is referred to;

FIG. 32 is a block diagram showing another configuration of the motion vector conversion apparatus;

FIG. 33 is a block diagram showing a further configuration of the motion vector conversion apparatus.

FIG. 34 is a block diagram showing a still further configuration of the motion vector conversion apparatus;

FIG. 35 is a diagrammatic view illustrating a method of converting a VOP converted from an intra-frame into a P-VOP to which a motion vector conversion method of the present invention is applied;

FIG. 36 is a block diagram showing a motion vector conversion apparatus to which the present invention is applied; and

FIG. 37 is a block diagram showing an example of an I to P motion vector conversion apparatus to which the present invention is applied.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 35, there is illustrated a method of converting a VOP converted from an intra-frame into a P-VOP to which the present invention is applied. Where the pertaining frame is an intra-frame, since it does not

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have a motion vector, motion compensation prediction

cannot be utilized for image coding of the frame,

resulting in a reduction in coding efficiency. Therefore,

in order to produce a motion vector to be utilized for

motion compensation prediction, motion vectors of a P

frame immediately preceding to the intra-frame to be

dropped are stored into a buffer, and scaling for spatial

and temporal modification described above is performed to

duplicate the motion vectors on macro blocks at the same

positions of the pertaining frame. Then, since the

immediately preceding P frame is dropped, the time

interval to a reference frame becomes doubled. Therefore,

the copied motion vectors are extended to twice in the

temporal direction to perform modification so that

another P frame immediately preceding to the P frame to

be dropped is referred to.

FIG. 36 shows a configuration of a motion vector

conversion apparatus to which the present invention is

applied. The motion vector conversion apparatus

corresponds to the motion vector conversion apparatus 6

of FIG. 2. A switch 381 operates in response to an I to

P-VOP motion vector (MV) conversion flag such that it is

switched to an I to P-VOP motion vector conversion

apparatus 382 side when the pertaining frame is an MPEG2

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intra-frame to be converted into an MPEG4 frame and the immediately preceding MPEG2 frame is a P frame, but it is switched to a P to P-VOP motion vector conversion apparatus 383 side when the pertaining frame is any other frame.

The I to P-VOP motion vector conversion apparatus 382 is described below. The P to P-VOP motion vector conversion apparatus 383 performs processing similar to that of the motion vector conversion apparatus described hereinabove with reference to FIG. 2 in the description of the related art.

FIG. 37 shows a configuration of the I to P-VOP motion vector conversion apparatus. Referring to FIG. 37, motion vectors of a P frame immediately preceding to an I frame to be dropped are stored into an MPEG2 motion vector buffer 371 first. The motion vectors of the macro blocks at the same positions in the P frame to be dropped are duplicated into the macro blocks of the I frame. An MPEG2 to MPEG4 8 × 8 MV conversion apparatus 372 extends, after it performs spatial and temporal modification of the motion vectors described hereinabove in the description of the related art, the motion vectors to twice in the temporal direction so as to refer to a P frame immediately prior to the P frame to be dropped.

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Each of the thus converted 8 × 8 motion vectors of MPEG4 is inputted to a 0 MV-prediction residual comparison apparatus 373, by which a prediction residual of the 0 motion vector and a prediction residual of the 8 × 8 motion vector thus produced are compared with each other. Then, if the prediction residual of the 0 motion vector is smaller than the prediction residual of the produced 8 × 8 motion vector, then the 8 × 8 motion vector is replaced with 0. The 8 × 8 motion vector thus outputted from the 0 MV-prediction residual comparison apparatus 373 is used by a motion vector integer pixel search apparatus 374 to perform a re-search within an arbitrary search window designated with an integer pixel value in accordance with a method similar to that described hereinabove in the description of the related art to improve the prediction accuracy of the motion vector.

Then, an 8 × 8 MV to 16 × 16 MV conversion apparatus 375 receives the 8 × 8 motion vectors and the respective prediction residuals produced by the motion vector integer pixel search apparatus 374 as inputs thereto, and allocates the 8 × 8 motion vector of that one of four blocks cooperatively forming each of the macro blocks which exhibits the smallest prediction residual to a 16 × 16 motion vector and outputs the 16 ×

16 motion vector. A 0 MV-prediction residual comparison apparatus 376 receives the 16 × 16 motion vector produced by the 8 × 8 MV to 16 × 16 MV conversion apparatus 375 as an input thereto and compares it with the prediction residual of the 0 motion vector. If the prediction residual of the 0 motion vector is smaller than the produced 16 × 16 motion vector, then the 0 MV-prediction residual comparison apparatus 376 replaces the 16 × 16 motion vector with 0. The resulting 16 × 16 motion vector is inputted to a motion vector integer pixel search apparatus 377. The motion vector integer pixel search apparatus 377 performs a re-search for the 16 × 16 motion vector with integer pixels in accordance with the method described hereinabove in the description of the related art and outputs a resulting 16 × 16 motion vector. The 8 × 8 motion vectors and the 16 × 16 motion vector determined with integer pixel values are inputted to a motion vector half pixel search apparatus 378, from which 8 × 8 and 16 × 16 motion vectors of MPEG4 are outputted with a half pixel accuracy.

Although a bit stream representative of image compression information of MPEG2 is inputted and a bit stream representative of image compression information of MPEG4 is outputted as described above, the input and the

output are not limited to the specific ones described, but they may otherwise be bit streams representative of image compression information, for example, of MPEG-1 or H.263.

While preferred embodiments of the present invention have been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims.